CLAIMS

1. A transporter of a biodevice for transporting cells during a transport time period, the transporter comprising:

a motion-inducing apparatus configured to induce transportation of the cells along a transport path of the biodevice between other operative portions of the biodevice, the apparatus comprising an electrode arrangement configured to apply a non-uniform electric field to the cells; and

a transport control unit coupled to the motion-inducing apparatus to control transportation of the cells and providing control signals to the motion-inducing apparatus during the transport time period to:

induce a primary motion of the cells to drive transportation of the cells along the transport path; and

induce a secondary motion of the cells to discourage aggregation of the cells during transportation of the cells.

2. The transporter of claim 1 wherein the transport control unit is configured to operate the motion-inducing apparatus such that the primary and secondary motion occurs at least one of simultaneously during the transport time period and alternately during the transport time period.

3. The transporter of claim 1 wherein the motion-inducing apparatus includes a first apparatus that induces the primary motion and a second apparatus that induces the secondary motion.

4. The transporter of claim 3 wherein the first apparatus and the second apparatus are vertically disposed with respect to one another.

5. The transporter of claim 4 wherein the second apparatus is disposed on a first substrate and the first apparatus is disposed on a second substrate, with the first and second substrate being spaced from one another so that the

transport path extends generally parallel between the first apparatus and the second apparatus.

6. The transporter of claim 1 wherein the primary motion is induced by a fluid pressure flow drop along the transport path.

7. The transporter of claim 5 wherein the first apparatus comprises the electrode arrangement, which is configured to impart a traveling wave in the non-uniform electric field.

8. The transporter of claim 7 wherein the second apparatus comprises a portion of the electrode arrangement and comprises a plurality of elongate electrode elements arranged generally parallel to the direction of primary motion along the transport path, wherein the elongate electrode elements are configured to apply a non-traveling wave, spatially varying electric field between the elements to define a plurality of channels in the transport path to prevent cell aggregation along the transport path.

9. The transporter of claim 4 wherein the first apparatus is overlaid onto the second apparatus in a single substrate, with both the first apparatus and the second apparatus disposed underneath the transport path, and wherein the second apparatus comprises a piezoelectric device configured to apply a vibratory force to the cells for preventing aggregation of the cells during the transport time period.

10. The transporter of claim 3 wherein the second apparatus is a plurality of electrode elements disposed on at least one of a top substrate and a bottom substrate, with the plurality of electrode elements including a first outer set and a second outer set of electrode elements, with the first outer set disposed on a first side of the transport path and the second outer set disposed on a second side of the transport path, and wherein the electrode elements within each of

the respective first outer sets and second outer sets are longitudinally spaced from each other along the transport path.

11. The transporter of claim 10 wherein the first and second outer sets of electrode elements are disposed on the bottom substrate, and the electrode arrangement further comprises a central electrode array of electrode elements that is disposed underneath the transport path centrally between the first outer set and the second outer set of electrode elements.

12. The transporter of claim 11 wherein each electrode element of the central electrode array corresponds to, and is aligned generally parallel to, one electrode element of each of first outer set and second outer set of electrode elements, which are located laterally relative to each electrode element of the central electrode array on opposite sides of the corresponding electrode element of the central electrode array.

13. The transporter of claim 12 wherein the transport control unit operates the first and second outer sets of electrode elements in a mode that applies a traveling wave in the non-uniform electric field in cooperation with the central electrode array.

14. The transporter of claim 12 wherein the transport control unit operates the first and second outer sets of electrode elements in a mode that applies the non-uniform electric field to deliver the secondary motion as an electro-rotational force on the cells.

15. The transporter of claim 12 wherein the transport control unit operates the first and second outer sets of electrode elements in a mode that applies the non-uniform electric field within the transport path to the cells to move the cells toward a center of the transport path.

16. The transporter of claim 12 wherein the transport control unit operates the first and second outer sets of electrode elements in at least two of three modes including:

a first mode that applies a first traveling wave in the non-uniform electric field in cooperation with the central electrode array;

a second mode that applies a second non-uniform electric field to deliver the secondary motion as an electrorotational force on the cells; and

a third mode that applies a third non-uniform electric field within the transport path to the cells to move the cells toward a center of the transport path.

17. The transporter of claim 12 wherein all the outer electrode elements and the central electrode array operate as the first apparatus in a first time period, and wherein in a second time period, only the central electrode array operates as the first apparatus.

18. The transporter of claim 1 wherein the electrode arrangement of the motion-inducing apparatus is configured to apply the non-uniform electric field as a temporally varying non-uniform electric field.

19. An apparatus for moving cells on an electronic biodevice during a transport time period, the apparatus comprising:

means for imparting a primary motion of the cells on the biodevice to transport the cells between stations on the biodevice, and a secondary motion of the cells to prevent aggregation of the cells during the cell transport; and

means for controlling the means for imparting, via control signals, to selectively activate the primary motion and the secondary motion to maintain substantially aggregation-free transport of the cells during the transport time period.

20. The apparatus of claim 19 wherein the means for imparting a primary motion of the cells comprises an electrode array having a first portion configured to apply a traveling wave dielectrophoretic field.

21. The apparatus of claim 20 wherein the electrode array has a second portion configured to apply at least one of the traveling wave dielectrophoretic field with the first portion and a dielectrophoretic field configured for imparting the secondary motion, wherein the second portion produces at least one of an electrorotative effect on the cells that rotates the cells and a centering effect on the cells that moves the cells toward a center of the transport path.

22. The apparatus of claim 21 wherein the means for imparting the secondary motion of the cells comprises a piezoelectric device disposed below the first portion of the electrode array, wherein the piezoelectric device is configured to apply an ultrasonic force on the cells.

23. The apparatus of claim 20 wherein the means for controlling the means for imparting comprises a transport control unit configured to apply the primary motion and the secondary motion in alternating cycles, wherein the primary motion is produced by the first portion of the electrode array and comprises at least one of the traveling wave dielectrophoretic field and a fluid flow pressure drop, and wherein the secondary motion comprises at least one of a negative dielectrophoretic field and an ultrasonic force wave.

24. The apparatus of claim 23 wherein the transport control unit is configured to also apply the primary motion and the secondary motion simultaneously.

25. A method of transporting cells comprising:

transporting a plurality of cells through a transport path of a biodevice; and

maintaining substantially free individual movement of each cell during the transporting of the cells through the transport path.

26. The method of claim 25 wherein transporting the cells comprises applying a traveling wave dielectrophoretic field to move the cells in a first direction through the transport path.

27. The method of claim 26 wherein maintaining substantially free individual movement of each cell comprises:

moving the cells in a multi-directional manner, within the transport path, that avoids disrupting movement of the cells in the first direction while preventing aggregation of the cells together and preventing adhesion of the cells to the transport path.

28. The method of claim 27 wherein maintaining substantially free individual movement of each cell comprises:

applying at least one of a dielectrophoretic field and a field of ultrasonic waves to the cells.

29. The method of claim 27 and further comprising:

cycling between moving the cells in the multi-directional manner to maintain substantially free individual cell movement and applying the traveling wave dielectrophoretic field to transport the cells in the first direction.

30. The method of claim 27 and further comprising:

simultaneously moving the cells in the multi-directional manner to maintain substantially free individual cell movement and applying the traveling wave dielectrophoretic field to transport the cells in the first direction.